

[54] METHOD FOR CONTROLLING OFFSHORE
PETROLEUM WELLS DURING BLOWOUT
CONDITIONS

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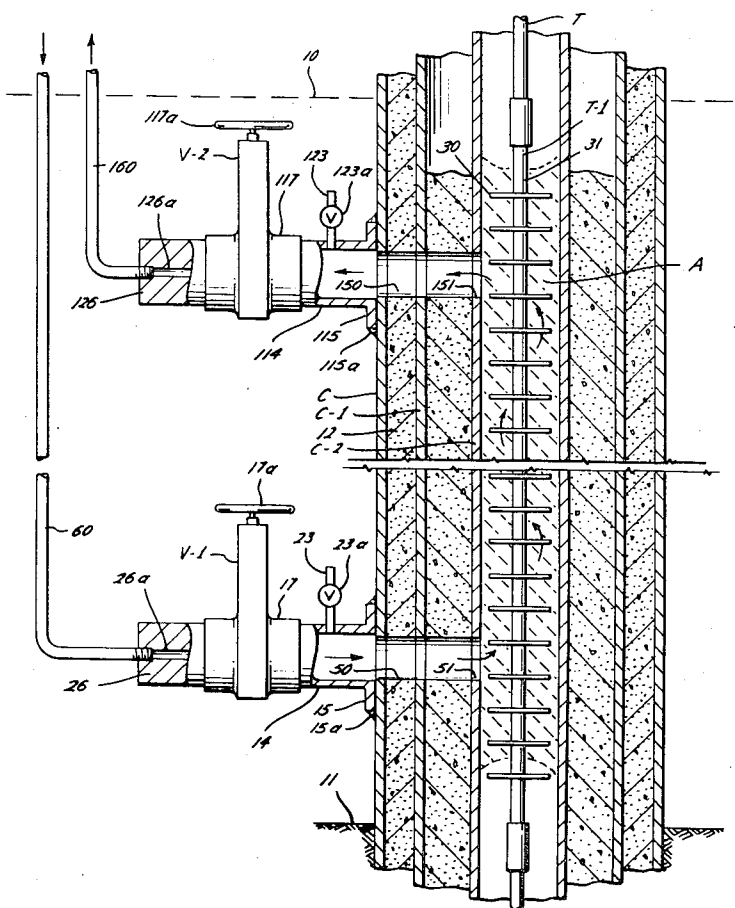
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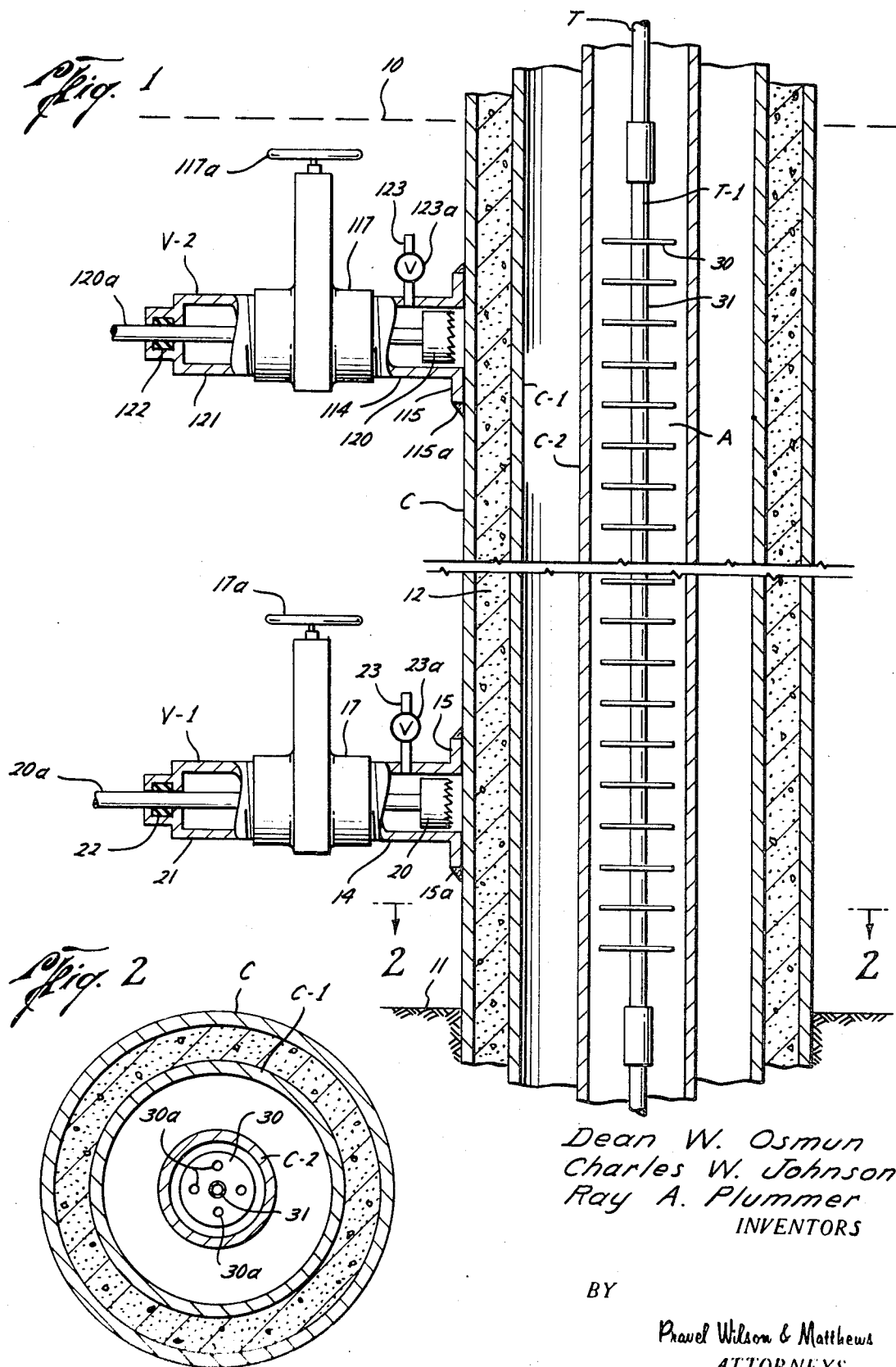
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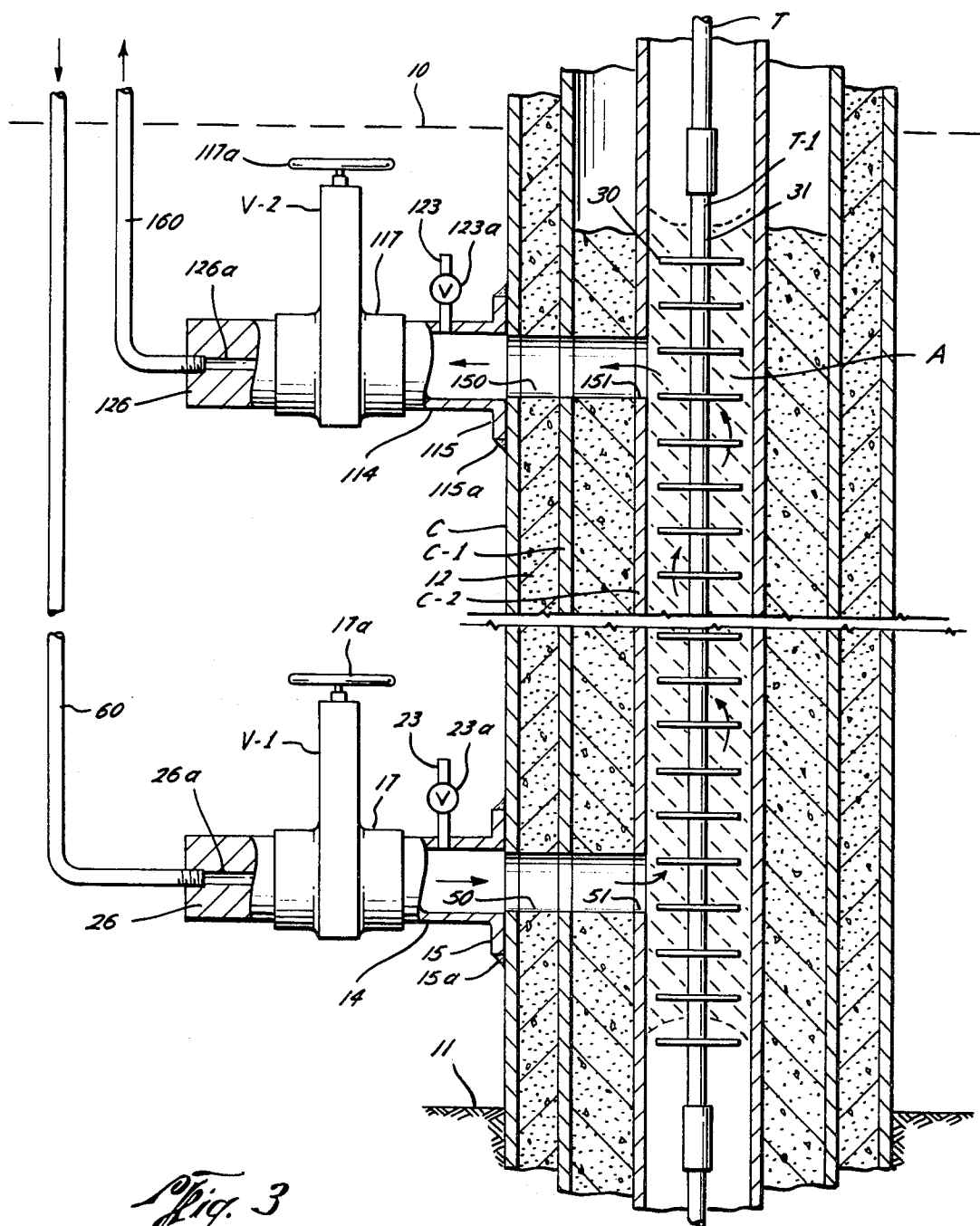
[57] ABSTRACT

Method for controlling petroleum wells, particularly those offshore, during blowout conditions, wherein special drill-through valves are externally mounted on a well casing at longitudinally spaced locations, and wherein openings are drilled or are otherwise formed through the wall of the casing at such valves to the area around or internally of the production tuning string so that various control operations may be performed, including for example, introducing liquid nitrogen and causing it to flow inwardly through one of said valves and out of the other of said valves for freezing a section of the petroleum, water and other material internally of the production string to form a temporary frozen plug which closes off fluid flow upwardly in the production string.

10 Claims, 3 Drawing Figures







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METHOD FOR CONTROLLING OFFSHORE PETROLEUM WELLS DURING BLOWOUT CONDITIONS

BACKGROUND OF THE INVENTION

The field of this invention relates to methods for controlling blowouts of petroleum wells.

In recent years, one of the most perplexing problems to the oil industry has been the control of petroleum wells during blowout conditions, particularly at offshore locations. Failure to control wells has resulted in fires, oil spills and other pollution, which is accentuated in connection with offshore wells. Various attempts have been made to solve this problem, but so far as is known, prior efforts have been largely directed towards the use of "storm" valves and other devices within the production string which are subject to malfunctioning in a well, especially when left in the well for extended periods prior to actual use. In fact, the most common types of storm valves or chokes used in offshore wells usually are damaged by sand or abrasives in the flowing petroleum so that they are often inoperable for shutting off the well when blowout conditions develop.

SUMMARY OF THE INVENTION

The present invention relates to new and improved methods for controlling petroleum wells, particularly those offshore, during blowout conditions. In carrying out this invention, a pair of valves are mounted externally on the well casing, usually below the waterline and above the ocean bottom, and then holes are drilled through the casing or casings to the annulus area around the production string. Thereafter, various well control operations may be performed, including, for example, introducing and circulating liquid nitrogen within the annulus around the production string for freezing the petroleum and other materials into a frozen plug to close off fluid flow upwardly in the production string. Under some circumstances, a hole or holes may be made in the production tubing itself for introducing the liquid nitrogen directly into the production tubing. Also, instead of freezing the fluid in the production string, mud may be pumped in to "kill" the well, and/or gas from the production string may be directed outwardly through one of the valves for its discharge or burning at a point remote from the well. Materials other than liquid nitrogen may also be pumped into the annulus or production string for controlling the well.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical sectional view, partly in elevation, illustrating one form of the apparatus used in carrying out the method of this invention;

FIG. 2 is a horizontal cross-sectional view taken on line 2-2 of FIG. 1 to further illustrate the apparatus of FIG. 1; and

FIG. 3 is a view similar to FIG. 1, but illustrating another phase of the method of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the drawings, the letter C designates the surface casing or outermost casing of a petroleum well which extends from above the waterline 10 downwardly into the bottom 11 of the body of water. An intermediate casing C-1 is disposed inwardly of the surface casing C in the known manner, and inwardly thereof, the pro-

duction casing C-2 is disposed. A production tubing string T is positioned within the production casing C-2 in the usual manner, and preferably such production string T has a special freeze joint T-1 therewith, as will be more fully explained. An upper valve V-1 and a lower valve V-2, each of which may be of known construction, are welded or are otherwise affixed to the outermost casing C in the known manner, and as will be more fully explained. Briefly, the present invention involves the location of one or more of such valves V-1 and V-2 on the outermost casing C so that subsequently openings can be provided through the various casings to the tubing annulus A (FIG. 1) which surrounds the tubing string T so that fluid can be communicated thereto for effecting various well control operations. In the preferred form of the invention, liquid nitrogen is introduced around the freeze joint T-1 to form a solid frozen plug within the tubing string T which closes off further flow upwardly in the tubing string T to thereby bring the well under control under incipient blowout conditions.

Considering the invention more in detail, for purposes of explanation, the petroleum well is assumed to be located offshore as illustrated by the waterline 10 in FIGS. 1 and 3. However, as will be evident from a description hereinafter, the present invention could be utilized in conjunction with any well whether it is located on shore or off shore.

The valves V-1 and V-2 are preferably of the type known in the industry as a "Kopple" valve which have been known for installation on pipelines. The valves V-1 and V-2 are mounted on the outermost casing C below the waterline 10 and above the bottom 11 of the body of water in a typical offshore situation. Normally, the valves are located approximately twenty feet apart, although this will vary depending upon the particular operations to be performed. The valves V-1 and V-2 are installed by divers after the casing C has been set, and normally after the intermediate casing C-1 has also been set with cement 12 hardened therebetween.

The particular construction of the valves V-1 and V-2 may vary, and they are illustrated with respect to the essential components of each since the details thereof are well known in the art. Thus, the valve V-1 has an inner valve section 14 with a saddle or circular flange 15 that is adapted to seat upon and fully engage the external surface of the casing C so that such flange 15 may be welded at 15a by a circular weld to the casing C to form a water-tight seal therebetween. The valve section 14 is threaded or is otherwise coupled to a central valve section 17 having a gate valve or other type of valve internally thereof (not shown), which is operated by a suitable valve handle 17a. The valve is of the type which permits a substantially full opening of the bore of the valve section 17 for the purpose of passing a drill 20 therethrough, as will be more evident hereinafter. An outer valve section 21 is secured to the central valve section 17 and it is provided with a seal 22 through which a drill rod 20a extends for moving the drill bit 20 inwardly and outwardly, as will be more evident hereinafter. An auxiliary relief line 23 having a valve 23a therewith is in communication with the interior of the valve section 14 to provide for access to such section 14 inwardly of the valve in the valve section 17, as will be more evident hereinafter. It should be observed that the bit 20 is of such a size that it can be withdrawn into the valve housing 21 so that the valve

in the section 17 can be closed. After the valve in the section 17 is closed, a valve nipple section 26 having a passage 26a therethrough (FIG. 3) is substituted for the valve section 21, thereby removing the bit 20 from the valve V-1 completely as will be more fully explained.

The valve V-2 is preferably of the identical construction of the valve V-1 and therefore, in the drawings, the same numerals and letter designations are used, except that the valve V-2 has the prefix 1 ahead of the numerals.

In the preferred embodiment of this invention, the tubing string T includes the freeze joint T-1 which is preferably constructed as illustrated in FIGS. 1-3, wherein a plurality of radial disks 30 are welded or are otherwise affixed to the external surface of the central tube 31 of the joint T-1. To facilitate circulation and improve the rate at which the solids internally of the freeze joint T-1 become frozen, a plurality of openings 30a (FIG. 2) are provided through each of the disks 30. It should be noted that the external diameter of each disk 30 is such that it occupies a major portion of the annulus A in the preferred form of the invention, but there is sufficient annular area around the disks 30 and also through the openings 30a for the flow of liquid nitrogen or other fluid, as will be explained for the proper flow of such fluid during the performance of the method of this invention.

In carrying out the method of this invention, the freeze joint T-1, if used in the tubing string T, is disposed at a location so that it is above the mud line 11 and below the waterline 10. Normally the freeze joint T-1 is approximately 30 feet in length, although this may vary depending upon the operating conditions. The valves V-1 and V-2 are welded at the welds 15a and 115a to the surface casing C by divers who take the valves below the waterline 10 and perform the welding operations underneath the water. The valves V-1 and V-2 are welded after the surface casing C has been set, and the intermediate casing C-1 has also been set, and the cement 12 therebetween has hardened. These valves V-1 and V-2 may thus be applied very early in the installation of the well so that they are readily available when and if needed during the occurrence of blowout conditions. However, if such valves have not already been installed as a precautionary measure during the early stages of the installation of the well casing, as explained, they may be installed later, even after a blowout condition has developed since the welders may perform their operations externally of the danger area at the surface of the well where the fire or other oil blowout is occurring.

When it is desired to kill the well, and particularly to cut off the upward flow of oil or gas through the production tubing T, the drills 20 and 120 are operated by a conventional hydraulic motor drive connected to the drill rods 20 and 120a, as will be well understood. The drill 20 is used to drill through the surface casing C, cement 12 and the intermediate casing C-1. If there are several intermediate casings, the drill 20 is used to continue drilling on through them but not through the production casing C-2 at this time. This provides the passage 50 shown in FIG. 3. At this point, if there has not been any cement introduced into the annular space between the intermediate casing C-1 and the production casing C-2, cement, plastic or any other similar material is pumped in through the access tube 23, with the valve 23a open for such purpose. During such pumping

of the cement, the valve in the valve section 17 is closed, and the bit 20 is retracted into the chamber of the valve section 21 so that the well is under control at all times. The cement is pumped in until the annulus between the intermediate casing C-1 and the production casing C-2 is filled at least above the upper valve V-2. After such cement or other hardenable material between such casings has set to a hardened condition, with the valve 23a closed, the valve in the section 17 is opened and the drill 20 is again moved inwardly to drill through such hardened cement and then through production casing C-2 to form the hole 51. The same procedure is preferably followed with the valve V-2 so as to form a hole or passage 150 through the casings C and C-1 and the cement 12 therebetween. The hole 150 may be formed after the introduction of the cement into the annular space between the intermediate casing C-1 and the production casing C-2, or it may be formed prior thereto. In any event, the hole 150 is continued on through such cement in the annular space between the casing C-1 and the casing C-2 and then a hole 151 which corresponds with the hole 51 therebelow is drilled with the drill 120 through the production casing C-2.

After all of the holes through the casings have thus been drilled with the drills 20 and 120, both of the drills are retracted into the tubing sections 21 and 121, respectively. Then, the valve handles 17a and 117a are operated to close the valves in the valve sections 17 and 117, respectively. The valve sections 21 and 121 are then removed together with the drills 20 and 120 and the parts connected therewith. The substitute fitting 26 is then connected to the valve V-1 and the substitute fitting 126 is connected to the valve V-2. Suitable pipes 60 and 160 are connected to the fittings 26 and 126, respectively, for extending to the surface above the waterline 10 so that the subsequent operations may be conducted from the surface at the well platform or other similar location.

In the preferred form of the invention, liquid nitrogen is introduced through the tubing or pipe 60, with the valve V-1 fully open. The valve V-2 is also open so that the liquid nitrogen flows upwardly through the tubing annulus A around the freeze joint T-1 or such other portion of the tubing string T which is located between the openings 51 and 151. Since the liquid nitrogen is at a temperature of minus 320° F., it freezes the water, hydrocarbons, carbon dioxide and other materials internally of the production tubing string T within the section exposed to the liquid nitrogen in the annulus A. The materials thus freeze into a solid plug within the production tubing string T, which freezing action is facilitated by the heat transfer disks 30 on the freeze joint T-1, and such plug closes off further upward flow of gas, or other petroleum products through the tubing string T. The well is thus brought under control and suitable surface valves may then be applied to the tubing string T. After suitable surface controls have been installed, the circulation of the liquid nitrogen may be discontinued and the valves V-1 and V-2 are then closed.

Although the invention is particularly suitable for the circulation of liquid nitrogen around the tubing string T as explained above, the method is not to be limited thereto. In some instances, the tubing string T can itself be penetrated by the drill 20 and also by the drill 120 so that a hardenable material such as an epoxy resin

can be introduced into the tubing string T to form a plug internally thereof for closing off fluid flow through such tubing string T. In other instances, the well may be brought under control by simply pumping mud or heavy liquid into the tubing annulus A to control any flow of petroleum gas or oil in the production casing C-2. If it is desirable to release gas which may be flowing out of control in the annulus A, the gas may be discharged through the tube 123 when the valve V-2 is closed and the valve 123 is open. Likewise, it is possible to drill a hole through the tubing string T adjacent one of the valves V-1 or V-2, and then gas may be permitted to discharge through either of the outlet lines 123 or 23 and thus escape for burning at a point remote from the well itself. This may be desirable to relieve excessive gas pressure and remove the location of any fire from the vicinity of the well so that well repairs may be made and well control devices may be installed as desired or necessary.

Although the invention has been specifically described using two of the valves V-1 and V-2, it should be understood that the method of this invention may be used in some circumstances, using only one of such valves, and in other cases, more than two of such valves may be employed.

The foregoing disclosure and description is merely exemplary of the invention and it will be understood that various modifications may be made therein, as will be understood by those skilled in the art.

We claim:

1. A method of controlling petroleum wells during blowout conditions wherein the well has one or more well casings and a production tubing string disposed internally of the casings, comprising the steps of:

mounting an upper valve and a lower valve in longitudinally spaced relationship on the external surface of the outermost well casing;

making a hole for each valve through the wall of the well casing for communicating the tubing annulus around a production string with each of the valves; and

thereafter manipulating said valves for controlling fluid flow between said tubing annulus and said valves.

2. The method set forth in claim 1, including: circulating liquid nitrogen in said tubing annulus and through said valves for freezing the materials in a section of said production string exposed thereto to thereby form a frozen plug closing off upward fluid flow in said production string.

3. The method set forth in claim 1, including: making the hole for each valve extend through the wall of said production tubing; and thereafter introducing fluid into the production string for controlling the flow of fluid therein.

4. The method set forth in claim 1, including: making the hole for each valve extend through the wall of said production tubing; and thereafter opening at least one of said valves for discharging fluid from the production string to the area externally of the outermost casing.

5. The method set forth in claim 1, wherein:

said valves are mounted on the outermost well casing below the waterline in an offshore well; and said hole for each valve is drilled through the well casing after each valve is mounted on the outermost well casing.

6. The method set forth in claim 1, wherein the well has at least one outer casing and an inner production casing with a casing annulus therebetween, including: initially making said hole for each valve through the wall of the outer casing and into communication with said casing annulus;

forcing a flowable hardenable material through at least one of said valves for sealing off said casing annulus to a point above the upper valve, and allowing such material to harden; and

thereafter making the holes for each valve through the hardened material and said production casing into said tubing annulus for thereby communicating said tubing annulus with each of said valves, whereby subsequent well control operations may be performed by said manipulating of said valves.

7. The method set forth in claim 6, including: circulating liquid nitrogen in said tubing annulus and through said valves for freezing the materials in a section of said production string exposed thereto to thereby form a frozen plug closing off upward fluid flow in said production string.

8. The method set forth in claim 1, including the step of:

including a tubing section in said production tubing string having a plurality of radially mounted disks thereon which are longitudinally spaced throughout the length thereof; and

positioning said valves and said holes in the casing in proximity to said tubing section for facilitating the freezing of the materials within said tubing section upon the circulation of liquid nitrogen in proximity thereto.

9. The method set forth in claim 7, including the step of:

circulating liquid nitrogen in said tubing annulus in the area of said disks of the tubing section and through said valves for freezing the materials in said tubing section to thereby form a frozen plug closing off upward fluid flow in said production string.

10. A method of controlling petroleum wells during blowout conditions wherein the well has one or more well casings and a production tubing string disposed internally of the casings, comprising the steps of:

mounting a valve on the external surface of the outermost well casing;

making a hole for the valve through the wall of the well casing for communicating the tubing annulus around a production string with the valve; and

thereafter introducing liquid nitrogen through the valve for freezing the materials in a section of said production string exposed thereto to form a frozen plug closing off upward fluid flow in said production string.

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